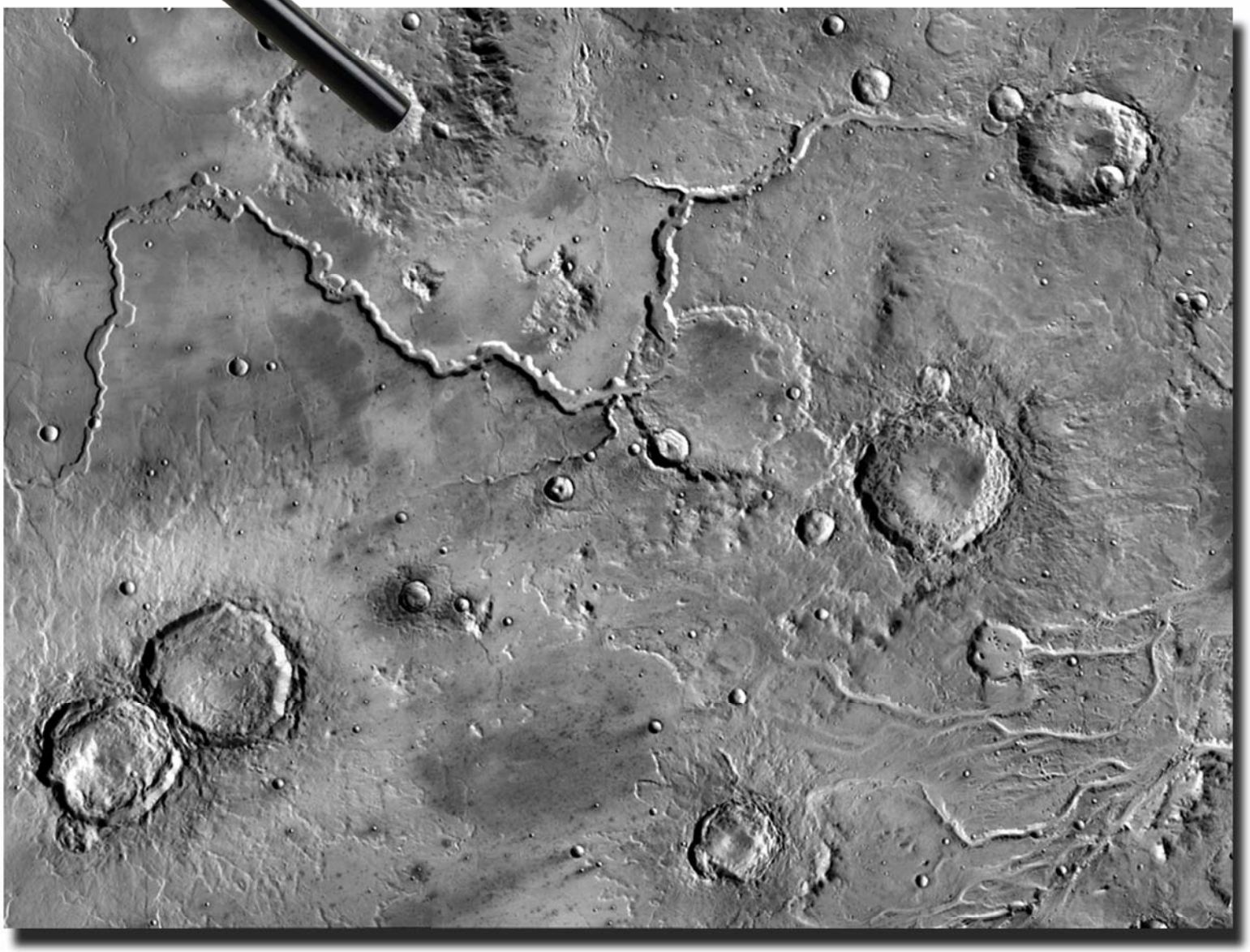
Arizona State University

National Aeronautics and Space Administration

Mars Uncovered

Revealing the Geologic History Through Mapping



An inquiry-based, critical thinking lesson about interpreting the geologic history of regions on Mars

STUDENT GUIDE

Student Worksheet 1

Initial Observations and Strategies

Name(s) _____

Date _____

Look at the Thermal Emission Imaging System (THEMIS) Daytime Infrared (IR) image mosaic your teacher has given you. You will be investigating this image throughout this activity looking for clues about the geologic history of this region. Areas where no THEMIS data has been acquired yet are seen as vertical black lines on the image.

1. What is the name of your region on Mars: _____

2. What are the two main geologic features seen in your image? Explain the process of how these features form.

   A. Geologic Feature: _____

      Formation:

   B. Geologic Feature: _____

      Formation:

3. List two pairs of geologic features (two craters, or a crater and a channel) that you feel you can determine which you feel is younger or older. Briefly describe where those features are located on your image mosaic (NW part of image, center of image, etc.):

   A. Two Features:_____ Location:_____

      Younger Feature:_____

      Older Feature:_____

   B. Two Features:_____ Location:_____

      Younger Feature:_____

      Older Feature:_____

4. Describe two strategies (methods) you used to determine which features are younger/older.

   A.

   B.

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Revealing the Geologic History Through Mapping

OBJECTIVE:
Make a simple geologic feature map of a region on the surface of Mars and using relative age dating techniques interpret its geologic history.

BACKGROUND INFORMATION:
Planetary scientists create maps of Mars in order to generate an interpretation of the geologic history of a particular region. These geologic feature maps show present day features and evidence of past events that have modified or changed a region. Scientists investigate these maps and look for clues to determine what geologic events have occurred. They do this by making observations of the surface features. Clues scientists use as part of their investigation are called relative age dating techniques. These techniques help infer a sequence of events that shaped a planetary surface. Exact dates can not be determined, but you can reconstruct a history to determine what event may have occurred before or after another. By determining the relative ages of features, the geologic history of a region can be inferred. On Earth, maps can be made by using photographs taken from airplanes or Earth-orbiting satellites. On Mars, maps can be made by using photographs (images) taken from orbiting spacecraft.

There are many images available of Mars. Over the past 30 years, NASA has sent landers, rovers and orbiters to image the martian surface. Cameras on orbiting spacecraft have taken numerous images from above the surface. Images taken of specific areas can be put together like a puzzle to create what is called a mosaic. Mosaics allow you to look at a large region of Mars. This allows scientists to map that region, analyze it, and interpret the geologic history.

This activity will put you in the role of a scientist. You will use mosaics created by images taken with the Thermal Emission Imaging System (THEMIS). This camera system is onboard the Mars Odyssey spacecraft. THEMIS has taken thousands of images of Mars that are available on the Internet (http://themis.asu.edu).

THEMIS (pictured on the left) is a two-in-one camera system:

- Visible Imaging System:
  - Shows the morphology or shape of the surface
- Infrared Imaging System:
  - Can tell us the temperature of the surface (daytime and nighttime)
  - Provides information about what materials on the surface are made of
  - Daytime infrared images can also show the morphology or shape of the surface in much the same way visible images do.

This activity will use daytime infrared image mosaics created by THEMIS. Although the infrared mosaics can provide information on both the morphology (the shape of the surface) as well as the temperature of the surface, for this activity, you will focus on the morphology of each region. This will allow you identify features such as craters and channels. As you go through the process of mapping a region it is important for you to be able to:

- Distinguish between preserved, modified and destroyed craters
- Understand different relative age dating principles

These are both considered relative age dating techniques that will allow you to better interpret the geologic history (a sequence of events that made a surface look the way it does today) of a region.

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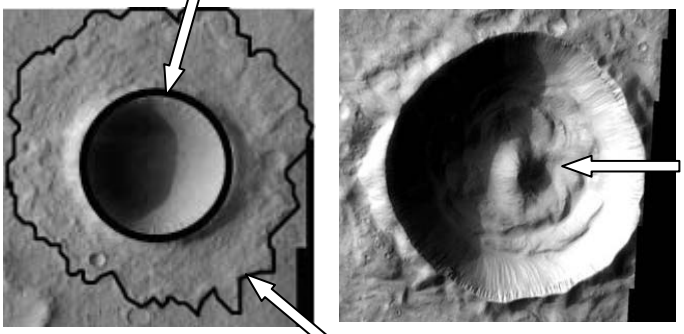
Crater Classifications

We can classify impact craters into three general categories based on their appearance. These three categories or classifications can help us understand the history (or relative age) of the crater. We can not identify the exact age of a crater on Mars, but the relative ages of different craters help us determine if one crater is older relative to another.

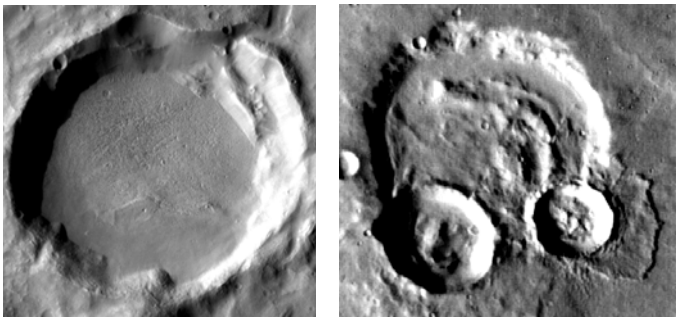
I. Preserved Craters:

- Near perfect craters
- Raised rims
- Look new
- Can sometimes see ejecta blanket or central peak
- Young crater



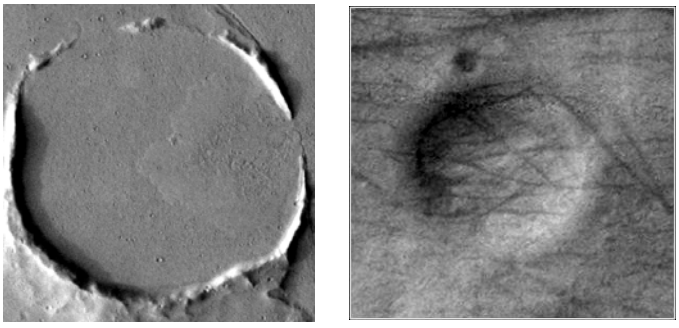
II. Modified Craters:

- Craters that have been changed or modified by:
  - Erosion (wind, water or lava)
  - Other impacts
- Sometimes crater ejecta is visible but looks eroded
- Crater may have smooth floor (partially filled in with material or sediment)
- Middle-aged craters



III. Destroyed Craters:

- Look very worn away
- Rims are broken
- Have been severely changed or modified
- Crater has been filled in almost completely by sediment
- Very old craters



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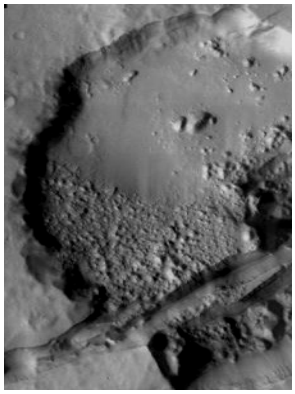
Relative Age Dating Principles

Scientists use two basic relative age dating principles (rules) that can be used to help determine the relative age of craters or other features on a surface. They are as follows:

I. Cross-Cutting Relationships:

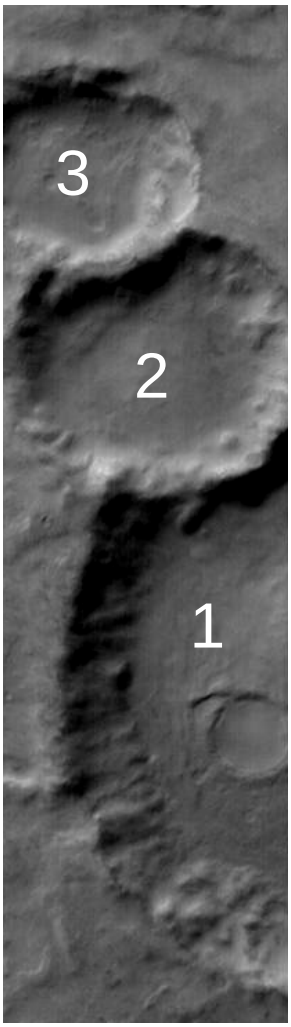
- A crater (or any other feature) can be cut by another feature.
- The feature cut is older than the feature that cut it.



Crater shown here is older than the fracture (crack) that cut through it.

II. Principle of Superposition

- When one feature is on top of another feature, the feature on top is younger.
- The feature on the bottom is the oldest feature.



Crater #1 is on the bottom of the two other craters and is therefore, the oldest.

Crater #2 is on top of crater #1 so it is younger than crater #1.

Crater #3 is on top of crater #2 so it is the youngest of all.

Student Worksheet II

Classifying Craters

Name(s) _____

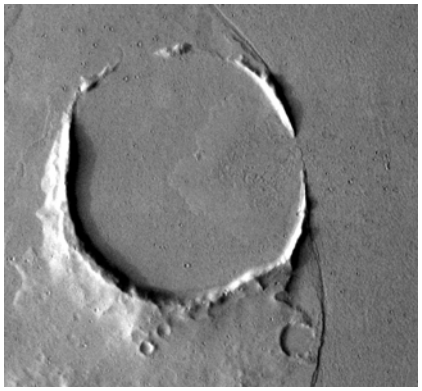
Date _____

Based on the *Crater Classification* information sheet, classify the craters at the bottom of the page. Be sure to explain your reasoning for each classification.

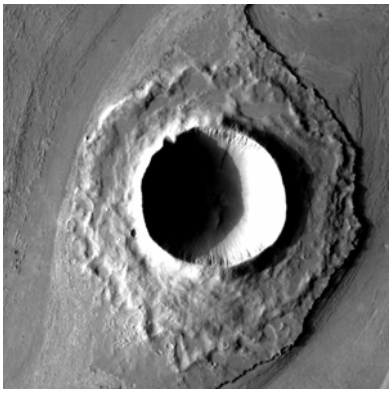
CRATER IMAGE	CRATER CLASSIFICATION: Preserved, Modified or Destroyed	REASONS
Crater A		
Crater B		
Crater C		
Crater D		

Crater A

Crater B



Crater C



Crater D

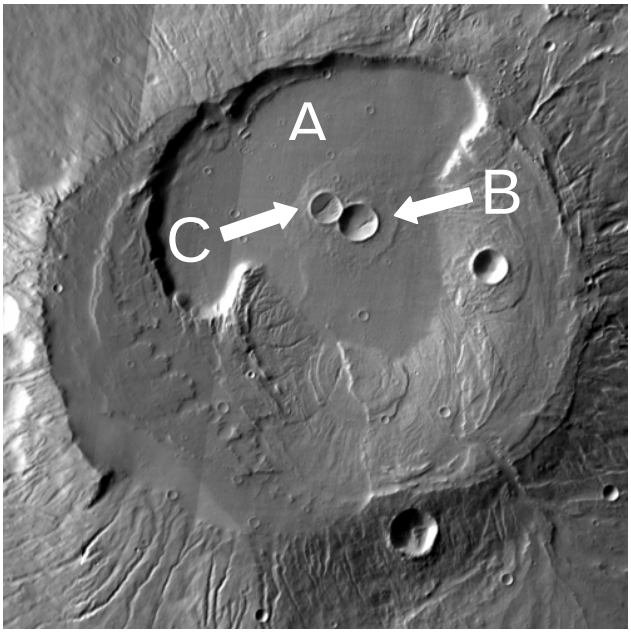
Student Worksheet III

Relative Age Dating Principles

Name(s) _____

Date _____

Based on the two relative age dating principles (cross-cutting relationships and superposition), write your interpretation of the relative ages of the features in the following images:



Oldest Crater: _____

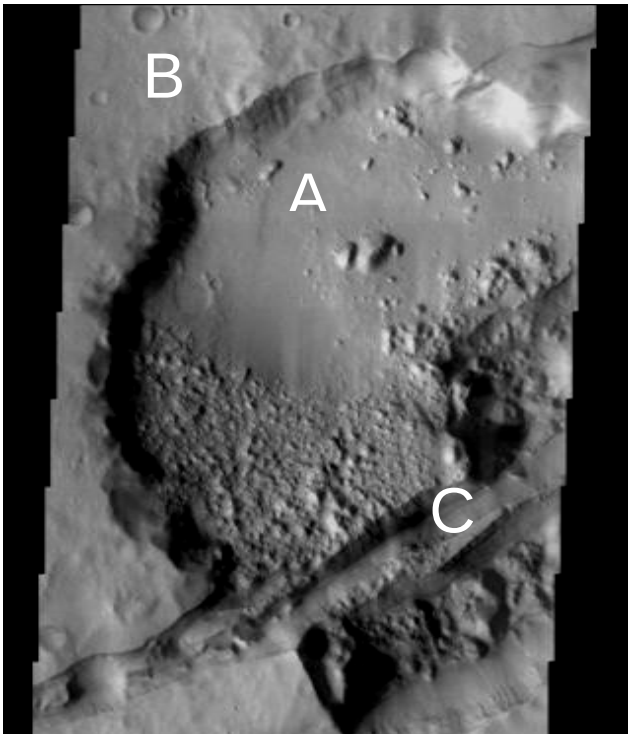
Younger Crater: _____

Youngest Crater: _____

Please explain your answers:

Which principle(s) did you use to choose your answer?

_____



Oldest Feature: _____

Younger Feature: _____

Youngest Feature: _____

Please explain your answers:

Which principle(s) did you use to choose your answer?

_____

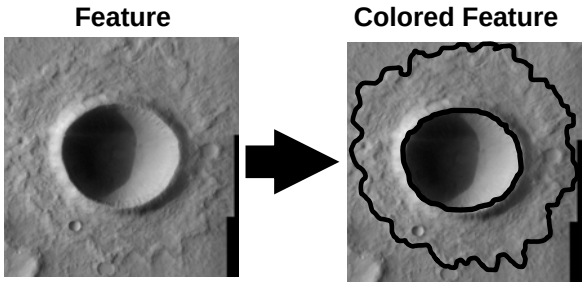
Student Worksheet IV

Creating a Surface Feature Map

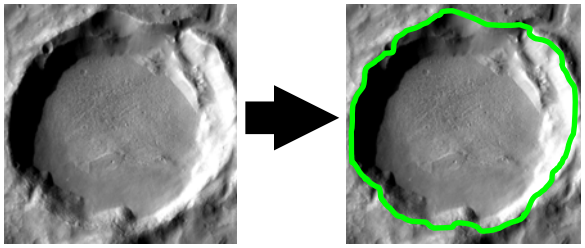
Now you know how to classify craters and are familiar with relative age dating principles. You can now create a feature map of your region of Mars that will help you interpret the geologic history.

In order to create your feature map, you will need to put a piece of transparency paper over your THEMIS mosaic image. Using paper clips, secure the THEMIS image and your paper together.

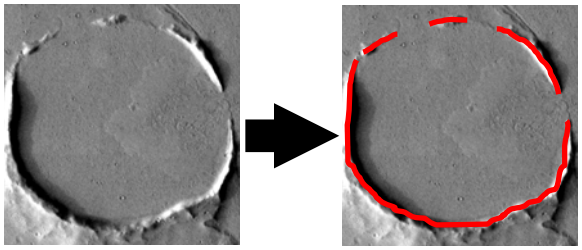
Using your observations and erasable markers, identify the features listed below to create your map. Keep in mind that some features may be too small to map. Use your best judgment to decide what may be too small to map and in determining how to the outline or color features. Outline or color the features as indicated below.



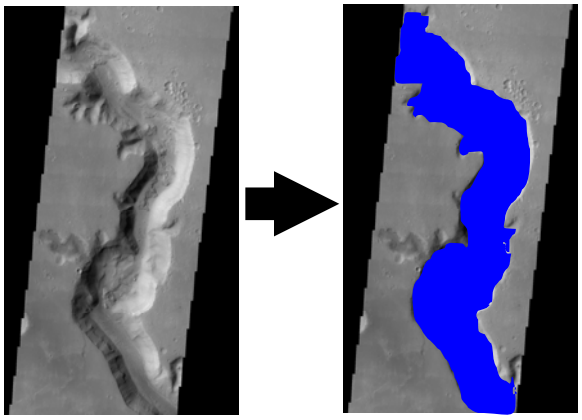
1. **Preserved Craters**: Carefully outline the rims and ejecta (if visible) of all preserved craters in **BLACK.**



2. **Modified Craters**: Carefully outline the uneven, or eroded rims and ejecta (if visible) of the modified craters in **GREEN.**



3. **Destroyed Craters**: Carefully outline the very eroded crater rims in **RED.**



4. **Channels:** Color (not outline) all channels in **BLUE.**

Student Worksheet V

Interpreting the Geologic History

Name(s) _____

Date _____

Once you have made your feature map, you are now able to answer some questions and interpret the geologic history of your region. Be sure to name the age dating technique you used for each answer.

REGION NAME: _____

1. Which is older – the channel(s) (blue) or the destroyed (red) craters? How do you know?

2. Which is older – the channel(s) (blue) or the modified (green) craters? How do you know?

3. Which is older – the channel(s) (blue) or preserved (black) craters? How do you know?

4. Which are older – most large craters or smaller craters? How do you know? Why do you think this is?

5. Which features are oldest, youngest, and of medium age?

Student Worksheet V

Interpreting the Geologic History
(cont'd)

6. Scientists don't always agree, but they try to convince each other with logical reasons for their interpretations. Discuss and defend your answers to questions #1 through #5 with another group that is studying the **same region**. Change any of your answers to questions #1 through #5 if you feel it is necessary. Fill out the table below after your discussion.

Question #	Did you agree or disagree with the other groups answer	Did you change your answer (yes or no AND why) (Be specific and use 'geologic reasons')
1		
2		
3		
4		
5		

7. Write your interpretation of the geologic history (the sequence of events that made this area look the way it does today) of this region of Mars. You can use this sample starting sentence or create your own. Use additional paper as necessary.

In the _____ region of Mars, there was a lot of geologic activity that modified the surface. First, what happened was…..

Student Worksheet VI

Initial Strategies and Future Investigations

Name(s) _____

Date _____

1. Look back at question #4 from *Student Worksheet I*. List each of your initial strategies in the first column provided below. In column two, indicate if you feel it was a valid scientific strategy (method) to use. Use the knowledge you acquired after completing the lesson to make this decision. In the third column, state the common scientific name (if one exists) for the strategy you listed (crater classification or one of the relative age dating principles). If you feel your strategy is valid but there is no name for that strategy, create a name for that strategy that you feel is appropriate. If you feel the scientific strategy is not valid, leave the last column blank.

Initial Strategy Used	**Valid Scientific Strategy (Yes or No)**	**Common Scientific Name (if applicable)**

2. After creating, observing and interpreting your feature map, list at least two questions you have about channels or craters on Mars and how would you go about investigating each question?

Question about craters or channels on Mars	**How would go about investigating your question?**
1.	
2.	

NOTES

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http://marsed.asu.edu
http://msip.asu.edu